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(56) Documents Cited

GB 2279677 A

GB 2261894 A

(58) Field of Search

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NONE

(54) Abstract Title

Cutting element with improved material toughness

(57) A cutting element which has a cutting table 14 made up of segments 16/18 of an ultra hard material. Each segment 16/18 may be made from a finer or a coarser grade of ultra hard material where the coarser is said to aid the cutters toughness and the finer to aid the cutters resistance to abrasion. The segments 16/18 are aligned side by side over a cutting face 12 of the cutting element to form the cutting table 14. The material grade and/or material type of each segment 16/18 may alternate across the cutting face. The segments 16/18 may also be arranged in a number of configurations for example concentric rings, linear chordwise strips, parallel strips and spiral strips.

FIG.1

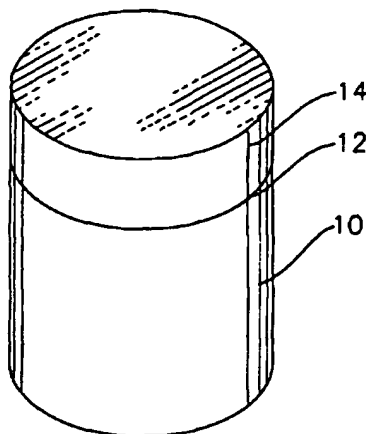


FIG.2

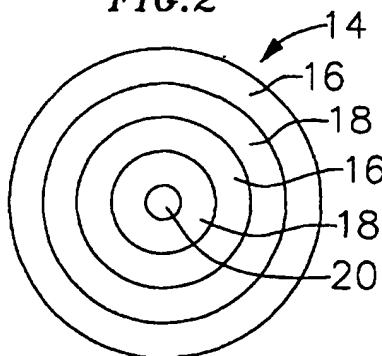


FIG. 1

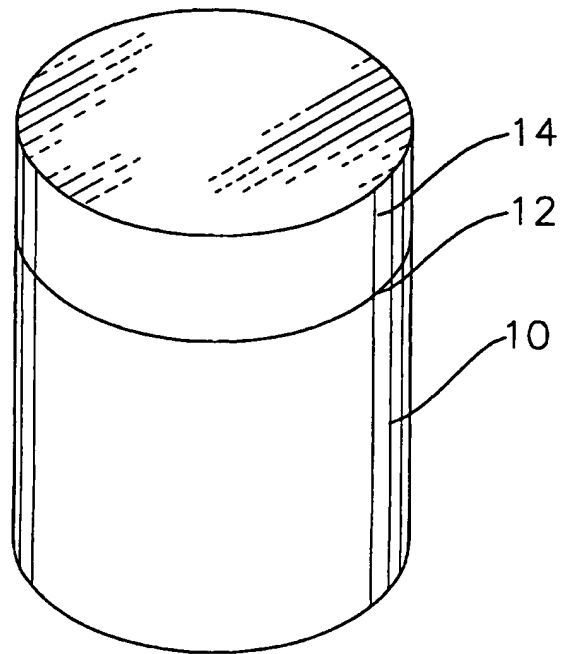


FIG. 2

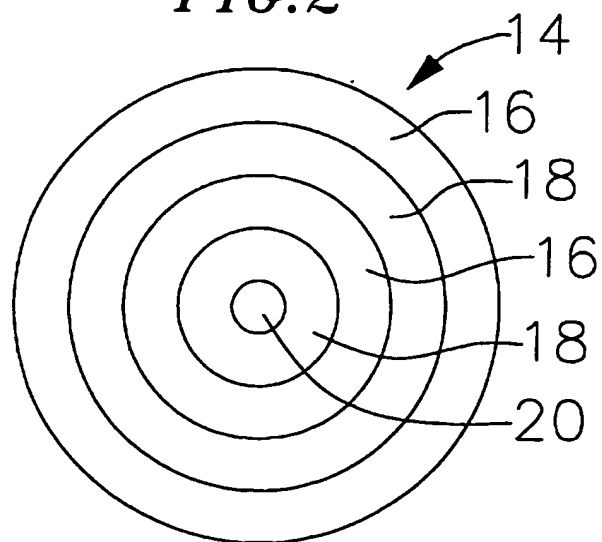


FIG. 3

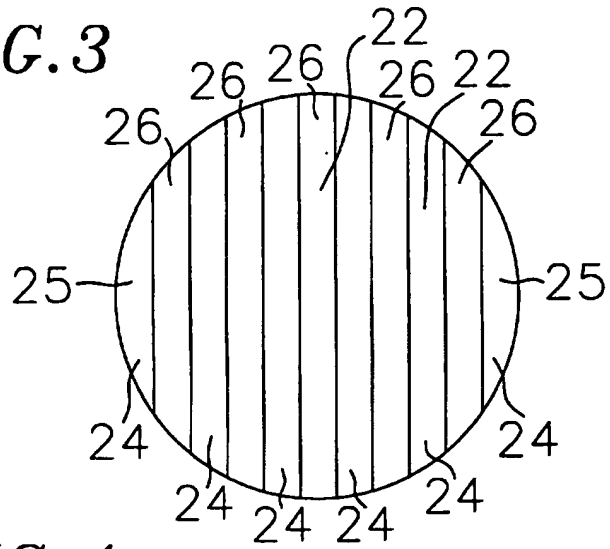


FIG. 4

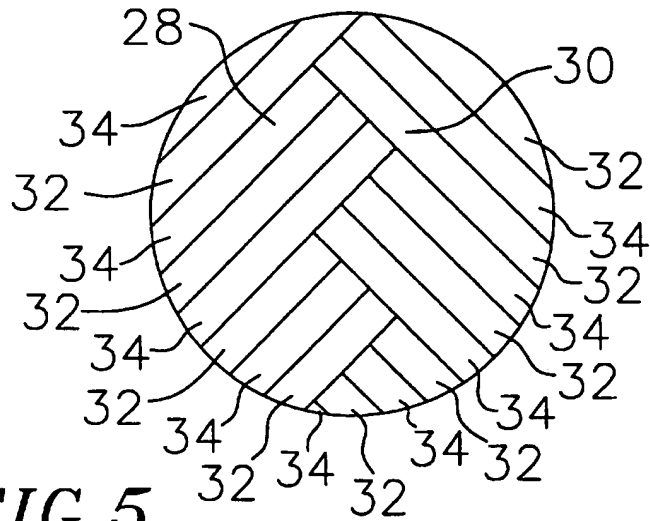


FIG. 5

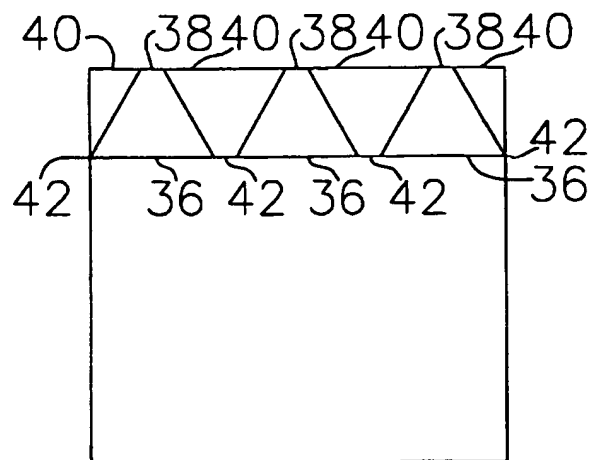


FIG. 6

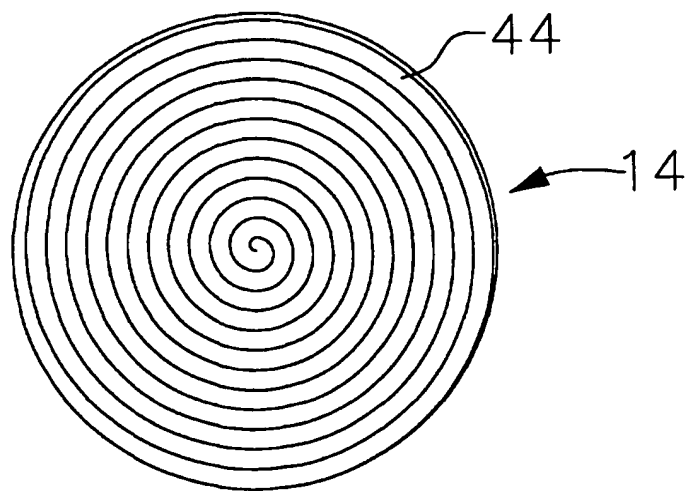
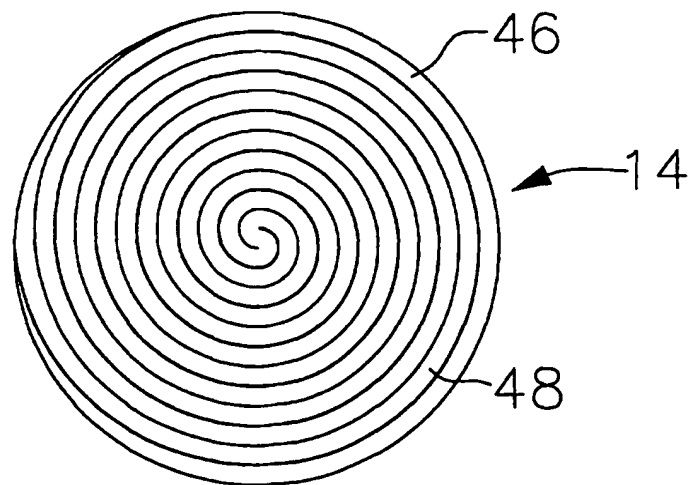


FIG. 7



**CUTTING ELEMENT WITH IMPROVED POLYCRYSTALLINE
MATERIAL TOUGHNESS AND METHOD FOR MAKING SAME**

This invention relates to cutting elements for use in a rock bit and more specifically to cutting elements which have a cutting table made up of segments of an ultra hard material.

A cutting element, such as a shear cutter shown in FIG. 1, typically has a cylindrical tungsten carbide substrate body 10 which has a cutting face 12. An ultra hard material cutting table 14 (i.e., layer) is bonded onto the substrate by a sintering process. The ultra hard material layer is typically a polycrystalline diamond or polycrystalline cubic boron nitride layer. During drilling, cracks form on the polycrystalline ultra hard material layer. These cracks are typically perpendicular to the earth formation being drilled. These cracks grow across the entire ultra hard material layer causing the failure of the layer and thus of the cutter. Growth of these cracks result in chipping, laminar type spalling and exfoliation. As such, there is a need for a cutting element having a cutting table that is capable of resisting crack growth.

The present invention is directed to a cutting element having a cutting table which is formed from segments of an ultra hard material. Preferably, some of the segments are made from finer grade of ultra hard material while the remaining segments are made from a coarser grade of ultra hard material. The segments alternate from a finer grade to a coarser grade across the cutting face of the cutting element. It is preferred that the finer grade material makes contact with the earth formation. As such, preferably, a finer grade segment makes up the edge of the cutting table making contact with the earth formation.

In an alternate embodiment, some of the segments are made from a first type of ultra hard material such a diamond, while the remainder of the segments are made from a second type of ultra hard material such as cubic boron nitride. With this embodiment, the segments form the cutting table and alternate from the first type of ultra hard material to the second type across the cutting table.

1 It is preferred that the segments are high shear compaction sheet segments which are
formed by slitting a high shear compaction sheet. The segments forming the cutting table can
be linear and parallel to each other, they may be concentric ring-shaped strips or spiraling strips.
Moreover, two sets of strips may be employed to form the cutting table wherein the strips within
5 each set are parallel to each other and wherein the first set is angled relative to the second set of
strips.

Embodiments of the invention will now be described, by
way of example, with reference to the accompanying diagrammatic
drawings, in which:

10 FIG. 1 is a perspective view of a typical shear cutter.

FIG. 2 is a top view of a cutting element prior to sintering having a cutting table made
of concentric ring-shaped ultra hard material strips.

FIG. 3 is a top view of a cutting element prior to sintering having a cutting table made
from linear parallel chordwise ultra hard material strips.

15 FIG. 4 is a top view of a cutting element prior to sintering having a cutting table made
of two sets of parallel ultra hard material strips, wherein the first set is angled relative to the
second set.

FIG. 5 is cross-sectional view of a cutting element prior to sintering having a cutting table
made of two sets of mated strips wherein the strips are tapered in cross-section such that the
20 strips of the first set are wider at the bottom and narrower at the top and the strips of the mated
second set are wider at the top and narrower at the bottom.

FIG. 6 is a top view of a cutting element prior to sintering having a cutting table formed
from a spiraling ultra hard material strip.

25 FIG. 7 is a top view of a cutting element prior to sintering having a cutting table formed
from two spiraling strips of ultra hard material.

30 This invention relates to cutting elements having cutting tables with enhanced toughness
and to a method of making such cutting elements. Cutting elements employed in rock bits that
have a variety of conventional shapes. For descriptive purposes, the present invention is
described in relation to a cylindrical cutting element. A cylindrical cutting element such as a
shear cutter as shown in FIG. 1 has a cylindrical cemented tungsten carbide body 10 which has
a cutting face 12. An ultra hard material layer 14 is bonded onto the cutting face and forms the
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1 cutting table. The ultra hard material layer is typically either a polycrystalline diamond (PCD) layer or a polycrystalline cubic boron nitride (PCBN) layer.

To enhance the toughness of the cutting table two or more dissimilar grades of the ultra hard material are alternated along the cutting face of the cutter. A finer grade ultra hard material
5 has higher abrasion resistance. A courser grade ultra hard material is known to be tougher.

Due to the nature of drilling, cracks form on the polycrystalline ultra hard material which are typically almost perpendicular to the earth formation being drilled. These cracks generally result in chipping, laminar type spalling and exfoliation. The present invention provides a way of arresting crack growth before it propagates across the entire cutting table thereby prolonging
10 the life of the cutting element.

The polycrystalline ultra hard material cutting table of the present invention is formed on the cutting face of the cutting element such that grade alternates from a finer grade to a coarser grade in a direction perpendicular to the formation. Preferably a finer grade would be used to do the cutting (i.e., will be in contact with the earth formation) while the coarser grade
15 would be used to arrest any crack grown. As such, a finer grade would preferably be located at the edge of the cutting table which would contact the earth formation. Typically, what would happen is that a crack will form proximate the edge and would start traveling perpendicular to the formation. Once the crack reaches the coarser material, crack growth would be arrested. As a result, the toughness of the polycrystalline cutting table is increased.

20 In a first embodiment shown in FIG. 2, the ultra hard material cutting table 14 is formed by placing ring-shaped concentric spaced apart segments 16 of a single ultra hard material grade over the cutting face of a presintered tungsten carbide substrate body. The spaces between the concentric rings are then fitted with a second set of concentric ring-shaped segments 18 made from a different grade of material. Once the segments are sintered, they form a polycrystalline
25 ultra hard material table which alternates in grade cross the cutting face. Preferably, the set of concentric segments which include the concentric segment forming the edge of the cutting table 14 are the finer grade segments. As it would become apparent to one skilled in the art, the centermost segment 20 will be circular and not ring-shaped.

In a further embodiment as shown in FIG. 3, chordwise segments (i.e., strips) 22 of the
30 ultra hard material are placed on top of the substrate cutting face and form the cutting element cutting table. These strips may be of a single grade or may be of multiple grades of ultra hard material. Preferably, two sets of strips are employed. The first set 24 is made from a finer grade of ultra hard material, while the second set 26 is made from a coarser grade of ultra hard material. Strips from the first set are alternated in parallel with strips from the second set along
35 the cutting element body cutting face. Strips from the first set, preferably make up the edges of

1 the cutting table that will contact the earth formation. As it would become apparent to one skilled in the art, one side of each of the edge strips 25 is curved so as to be aligned with the cutting element body.

5 In yet a further embodiment shown in FIG. 4, two sets of strips 28, 30 are used. The strips of the first set are positioned on the cutting element cutting face at an angle to the strips of the second set. The strips may be of a single grade or multiple grades of ultra hard material. Preferably, two grades 32, 34 are used wherein strips within each set alternate from strip of a finer grade to a strip of a coarser grade of ultra hard material.

10 To maximize the life of the cutting elements of the embodiments which have a cutting table formed from chordwise strip segments of ultra hard material, it is preferred that such cutting elements are mounted on the rock bit bodies so as to contact the earth formations at an angle perpendicular to the ultra hard material strips.

15 With any of the above embodiments, the segments may have cross-sections as shown in FIG. 5. For example, a set of spaced-apart segments may have a wider bottom 36 and a narrower top 38 in cross-section, while a second set of spaced-apart segments which is inter-fitted with the first set may have a wider top 40 and a narrower bottom 42 such that the second set is complementary to the first set as shown in FIG. 5.

20 With any of the above described embodiments, more than two different grade ultra hard material segments may be used. In such cases, it is preferred that the segments alternate from a first, to a second, to a third grade and so forth across the cutting table. In yet further embodiments, all of the ultra hard material segments employed in any of the above described embodiments may be formed from a single grade of ultra hard material. With these embodiments, the bond line between the successive segments would serve to divert and arrest crack growth. In yet further embodiments, instead of alternating segments of different grades of ultra hard material across the table, segments of different types of ultra hard materials are alternated across the cutting table. For example, diamond segments may be alternated with cubic boron nitride segments. These segments may contain ultra hard material of the same or different grades.

30 By being able to vary the material characteristics of the cutting layer across its face, the compressive residual stresses formed across the ultra hard material layer can be controlled or tailored for the task at hand. In other words, the residual compressive stress distribution on the ultra hard material layer can be engineered. For example, in the embodiment shown in FIG. 2, each ultra hard material ring-shaped segment may be made from a coarser material than the segment immediately radially outward from it. Since a coarser grade material shrinks less than a finer grade material during sintering, each segment will impose a compressive hoop stress on

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1 its immediately inward segment. As a result, a cutting layer will be formed having compressive hoop stresses.

With all of the aforementioned embodiments, it is preferred that the segments are cut from an ultra hard material tape, i.e., they are segments of the ultra hard material tape. Preferably, they are cut from a high shear compaction sheet of commingled ultra hard material and binder. Typically, such a high shear compaction sheet is composed of particles of ultra hard materials such as diamond or cubic boron nitride, and organic binders such as polypropylene carbonate and possibly residual solvent such as methyl ethyl ketone (MEK). The sheet of high shear compaction material is prepared in a multiple roller process. For example, a first rolling in a multiple roller high shear compaction process produces a sheet approximately 0.25 mm thick. This sheet is then lapped over itself and rolled for a second time, producing a sheet of about 0.45 mm in thickness. The sheet may be either folded or cut and stacked in multiple layer thickness.

This compaction process produces a high shear in the tape and results in extensive mastication of ultra hard particles, breaking off corners and edges but not cleaving them and creating a volume of relatively smaller particles in situ. This process also results in thorough mixing of the particles, which produces a uniform distribution of the larger and smaller particles throughout the high shear compaction material. The breakage rounds the particles without cleaving substantial numbers of the particles.

Also, high shear during the rolling process produces a sheet of high density, i.e., about 2.5 to 2.7 g/cm³, and preferably about 2.6 ± 0.05 g/cm³. This density is characteristic of a sheet having about 80 percent by weight diamond crystals (or cubic boron nitride crystals), and 20 percent organic binder. At times, it is desirable to include tungsten carbide particles and/or cobalt in the sheet. There may also be times when a higher proportion of binder and lower proportion of diamond or cubic boron nitride particles may be present in the sheet for enhanced "drapability." The desired density of the sheet can be adjusted proportionately and an equivalent sheet produced.

The sheet of high shear compaction material is characterized by a high green density, resulting in low shrinkage during firing. For example, sheets used on substrates with planar surfaces have densities of about 70 percent of theoretical density. The high density of the sheet and the uniform distribution of particles produced by the rolling process tend to result in less shrinkage during the presinter heating step and presintered ultra hard layers with very uniform particle distribution, which improves the results obtained from the high pressure, high temperature process.

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1 In yet a further alternate embodiment shown in FIG. 6, a spiraling strip 44 forms the
cutting table 14. To form the spiraling strip, preferably an ultra hard material high shear
compaction sheet is rolled into a roll. A slice is cut off the end of the roll. The slice which is
5 in the form of a spiraling strip is then bonded to the cutting element body cutting face forming
the cutting table.

 In another embodiment shown in FIG. 7, the cutting table 14 is formed from two spiraling
strips 46, 48 of an ultra hard material. It is preferred that each of the strips is made from a
different grade of the ultra hard material. Alternatively, each strip may be made from a different
type of ultra hard such as diamond and cubic boron nitride. To form the cutting table, preferably
10 a first ultra hard material high shear compaction sheet 48 is placed over a second ultra hard
material high shear compaction sheet 46. The two sheets are rolled forming a roll. An end of
the roll is sliced off. The sliced portion which is made up of two spiraling strips is bonded to the
cutting face of the cutting element body to form the cutting table.

1 CLAIMS

1. A cutting element comprising:
a body having a cutting face; and
5 a plurality of abutting side by side sheet segments of ultra hard material on the cutting face forming a cutting layer.
2. A cutting element as recited in claim 1 wherein the material grade of a first segment is different than the grade of a second segment.
- 10 3. A cutting element as recited in claim 1 wherein the segments alternate in a radial direction from the center of the cutting face between a finer and coarser material grade.
4. A cutting element as recited in claim 1 wherein a first segment comprises a first
15 type of ultra hard material and a second segment comprises a second type of ultra hard material that is different than the first type.
5. A cutting element as recited in claim 1 wherein the segments alternate in a radial direction from the center of the cutting face between a first and a second type of ultra hard
20 material.
6. A cutting element as recited in claim 1 wherein the segments are cut from a high shear compaction sheet of commingled ultra hard material and binder.
- 25 7. A cutting element as recited in claim 1 wherein the segments are concentric ring shaped strips.
8. A cutting element as recited in claim 7 wherein the ultra hard material forming each strip increases in coarseness for each radially inward strip.
- 30 9. A cutting element as recited in claim 7 wherein each strip causes compressive hoop stresses to be formed on a subsequent strip inward when the cutting layer is formed.
10. A cutting element as recited in claim 1 wherein the segments are linear chordwise
35 strips.

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11. A cutting element as recited in claim 1 wherein the segments are divided in two sets, a first set comprising parallel segments and a second set comprising parallel segments wherein the two sets are at an angle to each other.

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12. A cutting element comprising:
a body having a cutting face;
a first set of sheet segments of ultra hard material formed on the cutting face; and
a second set of sheet segments of ultra hard material formed on the cutting face

10 wherein the segments alternate along a radial direction from the center of the cutting face between the first and second sets.

13. A cutting element as recited in claim 12 wherein each segment of the first set comprises an upper surface and a lower surface wherein the upper surface is narrower than the
15 lower surface.

14. A cutting element as recited in claim 12 wherein each segment of the second set comprises an upper surface and a lower surface wherein the upper surface is wider than the lower
20 surface.

15. A cutting element as recite in claim 14 wherein the segments of the first set are complementary to the segments of the second set.

16. A cutting element as recited in claim 12 wherein the first set segments are made
25 from an ultra hard material grade that is different from the grade of ultra hard material making up the second set segments.

17. A cutting element as recited in claim 12 wherein one set of segments comprises diamond and the other set comprises cubic boron nitride.
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18. A cutting element as recited in claim 12 wherein the segments for each set are cut from high shear compaction sheets of commingled ultra hard material and binder.
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- 1 19. A cutting element comprising:
 a body having a cutting face; and
 a spiraling ultra hard material strip formed on the cutting face forming a cutting
5 table.
20. A cutting element as recited in claim 19 further comprising a second spiraling
 ultra hard material strip formed on the cutting face and spiraled within the first spiraling ultra
 hard material strip.
- 10 21. A cutting element as recited in claim 20 wherein the first ultra hard material strip
 is made from a grade of ultra hard material that is different than the grade of the second strip.
22. A cutting element as recited in claim 20 wherein the first ultra hard material strip
 comprises a first type of ultra hard material and the second ultra hard material strip comprises
15 a second type of ultra hard material different than the first type.
23. A cutting element as recited in claim 20 wherein each strip is cut from a high
 shear compaction sheet of commingled ultra hard material and binder.
- 20 24. A method for forming a cutting element comprising the steps of:
 forming a cutting element body having a cutting face;
 placing a plurality of side by side sheet segments of commingled ultra hard
 material and binder on the cutting face; and
 processing the body and segments at a temperature and pressure for forming a
25 polycrystalline ultra hard material layer from the segments.
25. A method as recited in claim 24 further comprising the steps of:
 determining a desired residual stress distribution on the ultra hard material layer;
 and
30 placing segments having different material properties on the cutting face in a
 pattern for forming a polycrystalline ultra hard material layer having the desired residual stress
 distribution.
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- 1 26. A method as recited in claim 24 further comprising the step of placing segments
from different sheets of commingled ultra hard material and binder across the cutting face,
wherein a segment from a first sheet is adjacent to a segment from a second sheet.
- 5 27. A method as recited in claim 24 wherein the step of placing further comprises the
steps of:
 slitting a sheet of commingled ultra hard material and binder into strip segments;
and
 positioning the strip segments in parallel on the cutting face.
- 10 28. A method as recited in claim 24 wherein the step of placing further comprises the
steps of:
 slitting a sheet of commingled ultra hard material and binder in strip segments;
and
15 positioning at least some of the strip segments at an angle to each other on the
cutting face.
29. A method as recited in claim 24 wherein the step of placing further comprises the
steps of:
20 cutting concentric ring shaped strip segments from a sheet of commingled ultra
hard material and binders; and
 positioning the strip segments over the cutting face.
30. A method for forming a cutting element comprising the steps of:
25 forming a cutting element body having a cutting face;
 forming a spiral strip from a sheet of commingled ultra hard material and binder;
 placing the strip on the cutting face; and
 processing the body and strip at sufficient pressure and temperature for forming
a polycrystalline ultra hard material layer from the strip on the body.
- 30 31. A method as recited in claim 30 wherein the forming step further comprises the
steps of:
 rolling a sheet of commingled ultra hard material and binder into a roll; and
 cutting a slice from the roll whereby the slice is in the form of a spiral strip.
- 35

1 32. A method as recited in claim 30 further comprising the steps of:
 forming a second spiral strip from a sheet of commingled ultra hard material and
 binder; and
 bonding the second spiral strip on the cutting face within the first spiral strip.

5 33. A method as recited in claim 32 wherein the first spiral strip is formed from a
 sheet comprising a grade of ultra hard material that is different than the grade of the ultra hard
 material forming the second spiral strip.

10 34. A method as recited in claim 32 wherein the first spiral strip comprises a first type
 of ultra hard material and the second spiral strip comprises a second type of ultra hard material,
 wherein the first type of ultra hard material is different than the second type of ultra hard
 material.

15 35. A method for forming a cutting element comprising the steps:
 forming a cutting element body having a cutting face;
 placing a first sheet of commingled ultra hard material and binder over a second
 sheet of commingled ultra hard material and binder;
 rolling the two sheets into a roll;
20 cutting a slice from the roll;
 placing the slice to the cutting face; and
 processing the body and slice at a sufficient temperature and pressure for forming
 a polycrystalline ultra hard material layer from the slice on the body.

25 36. A method as recited in claim 35 wherein each sheet comprises a different grade
 of ultra hard material.

 37. A method as recited in claim 35 wherein each sheet comprises a different type of
 ultra hard material.

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Claims searched: 1 - 37

Examiner: Andrew Jenner
Date of search: 19 May 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): E1F: FFR, FGA, FGB, FGC

Int Cl (Ed.6): E21B: 10/00, 10/46

Other: None

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2279677 A CAMCO DRILLING GROUP LTD. - whole document relevant.	1 - 8, 12 - 18, 24 - 29
X	GB 2261894 A CAMCO DRILLING GROUP LTD. - whole document relevant.	1 - 8, 10, 12 - 18, 24 - 29

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.